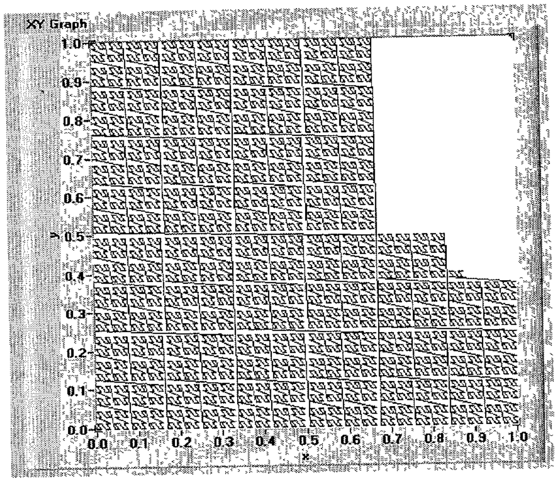
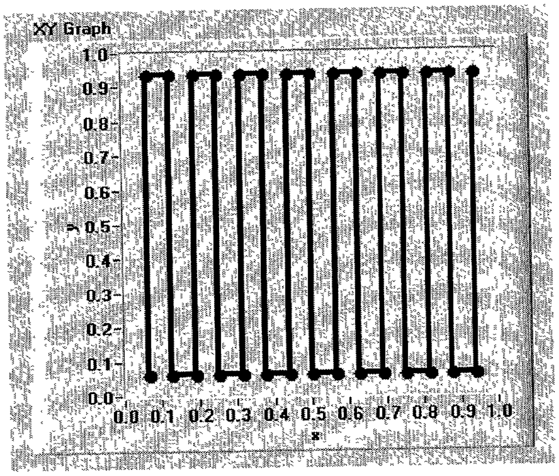


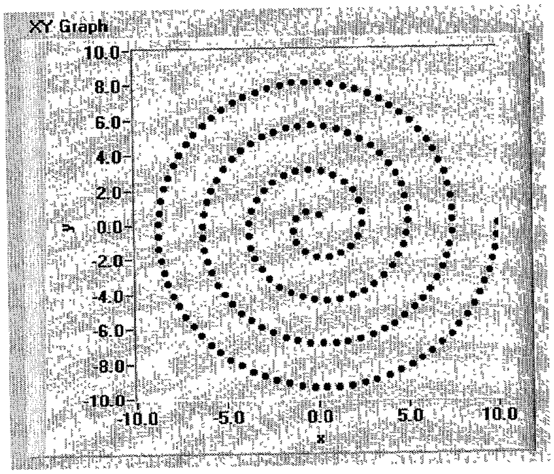
Approximated Peano Curve. The space-filling process has not been completed.

Figure 1A (Prior Art)



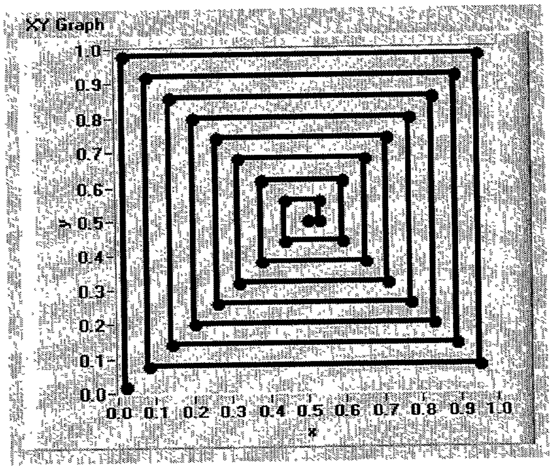
Boustrophedon Path

Figure 1B (Prior Art)



Archimedes Spiral defined by equally distributed points

Figure 1C (Prior Art)



Spiral-like line-based scanning

Figure 1D (Prior Art)

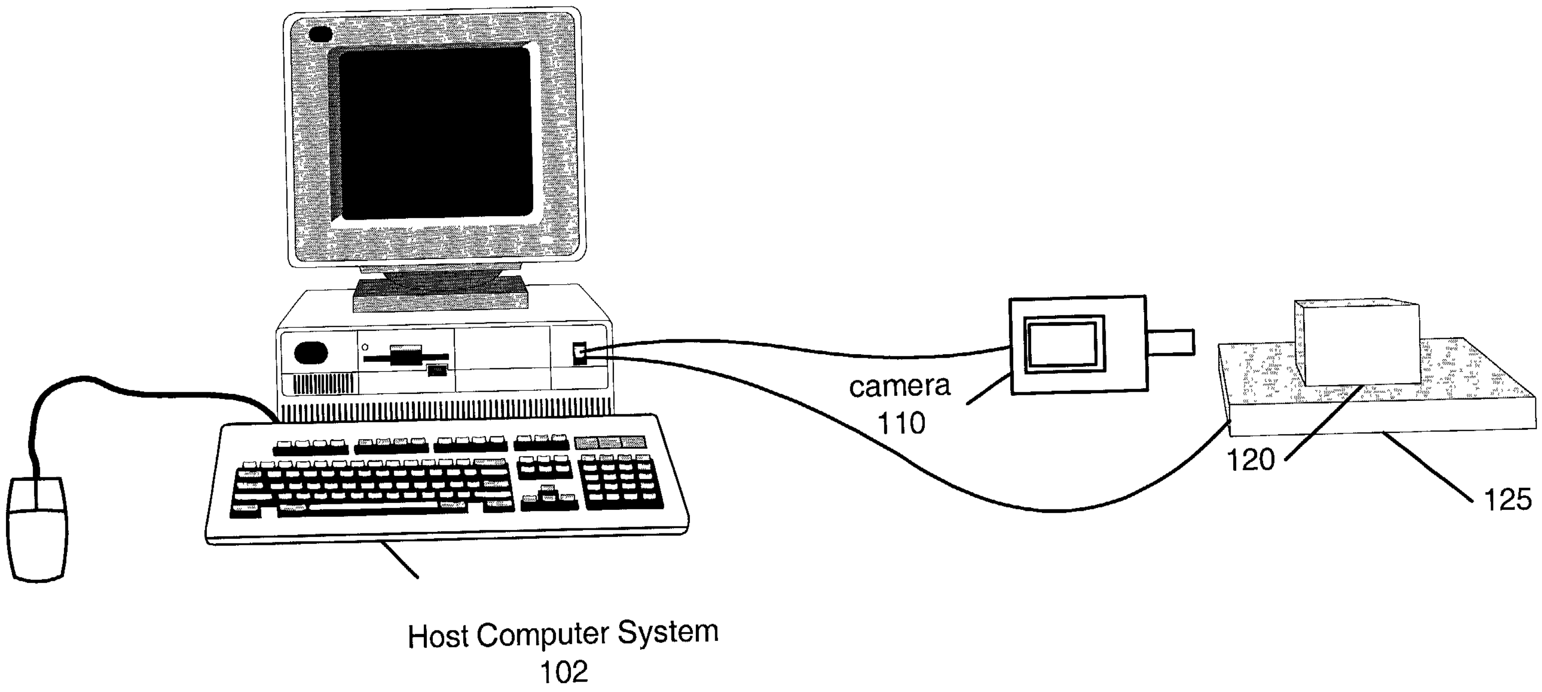


Figure 2A

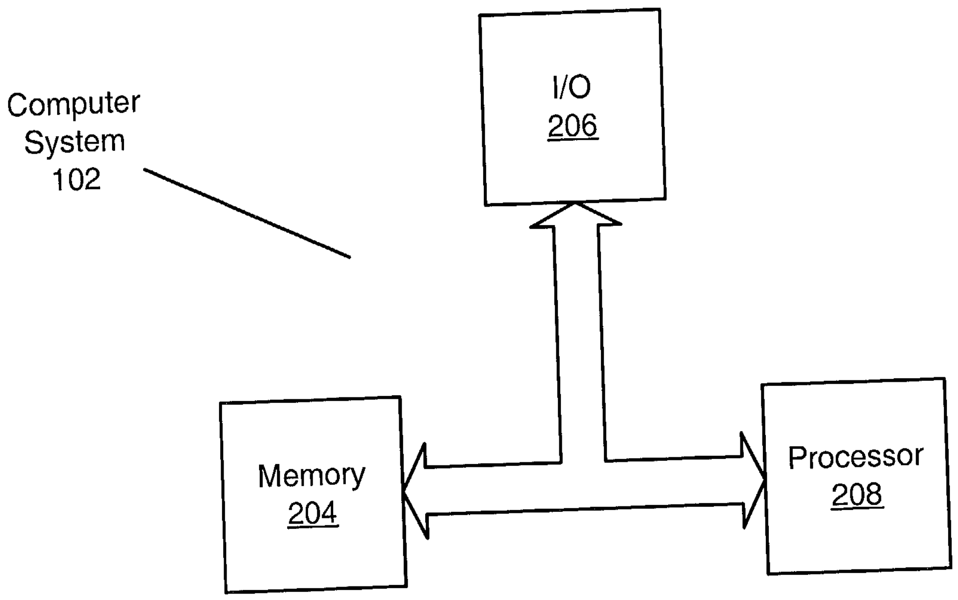


Figure 2B

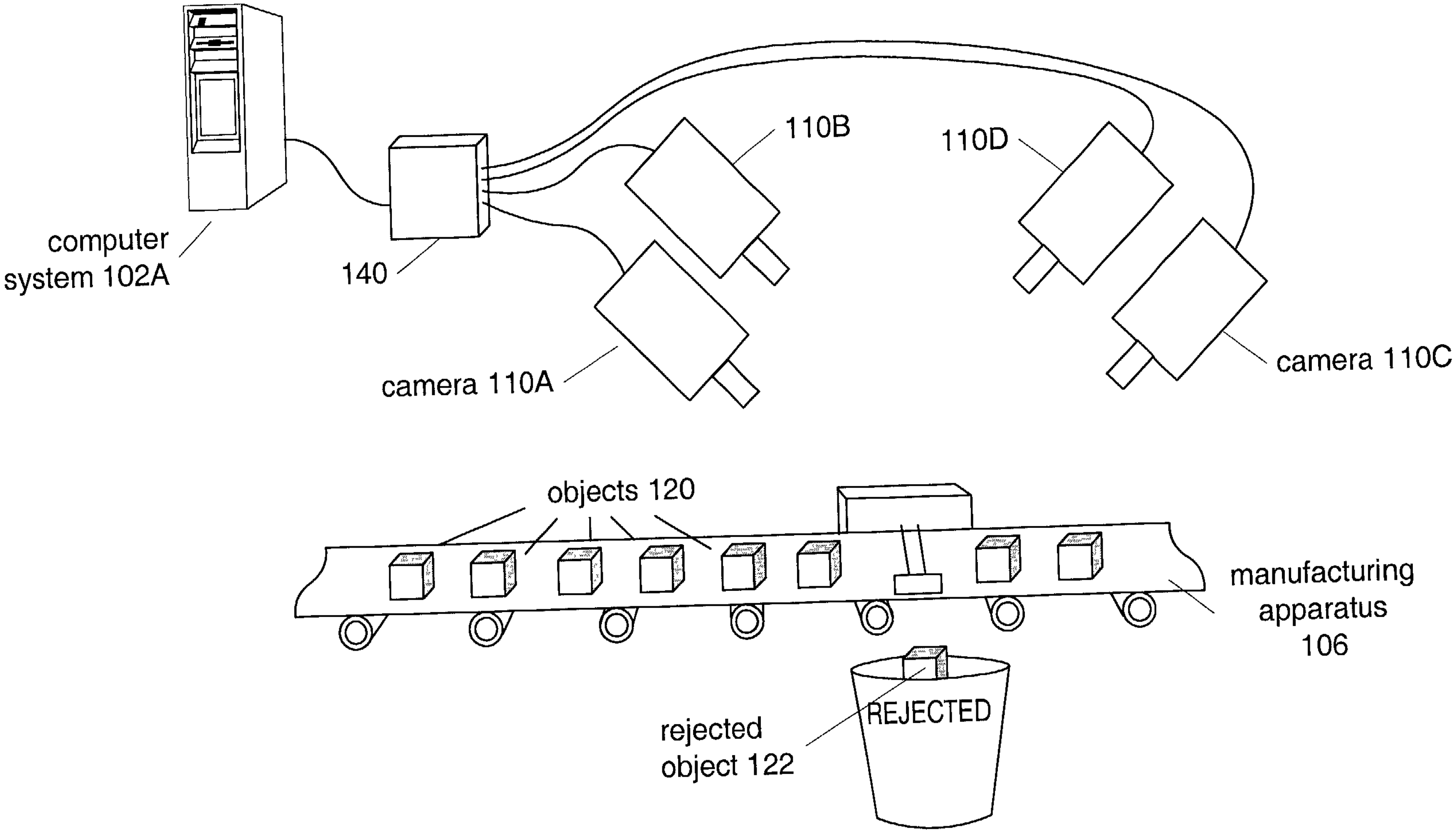

computer
system 102A
140
110B
110D
camera 110A
camera 110C
objects 120
manufacturing
apparatus
106
rejected
object 122
REJECTED

Figure 3A

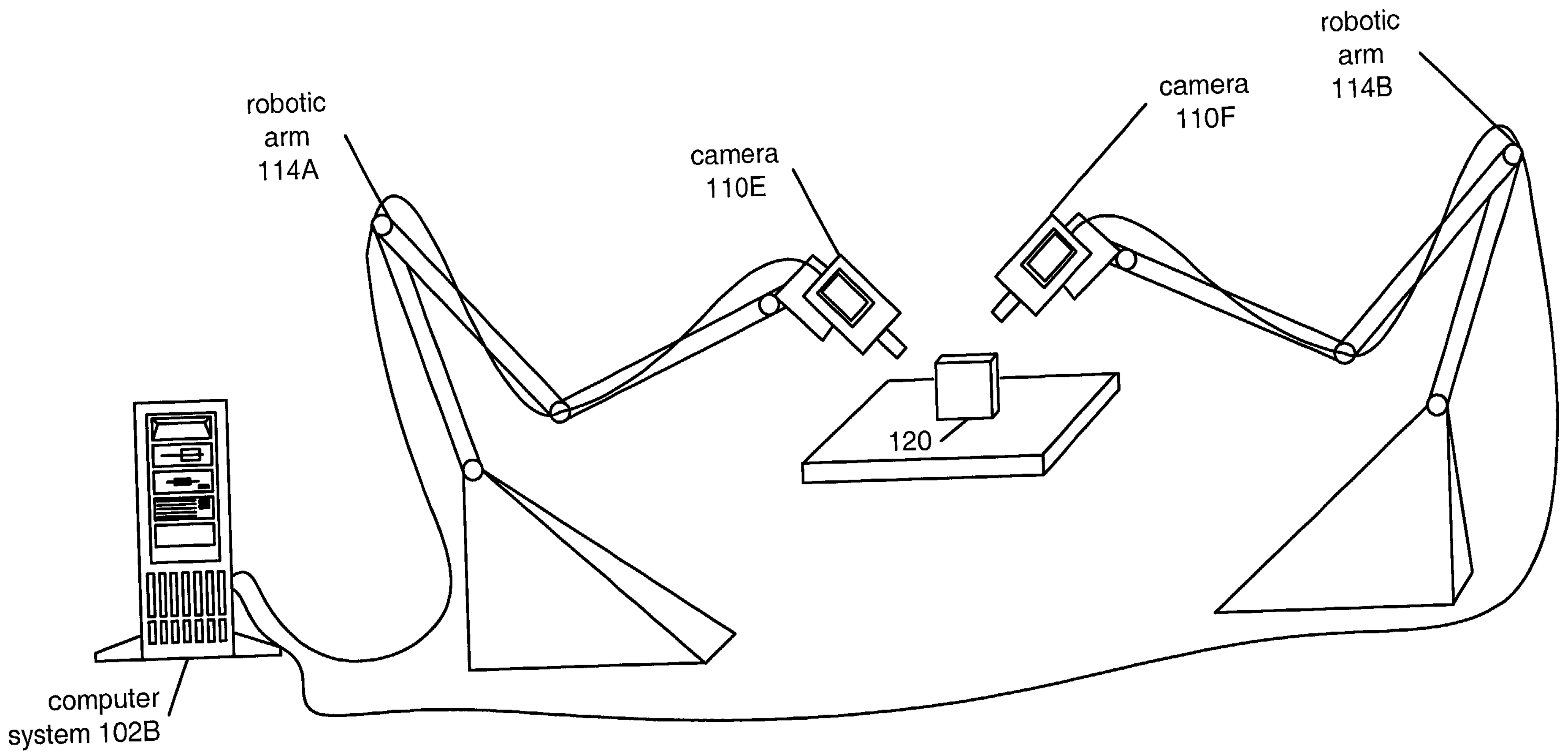

robotic
arm
114A
camera
110E
camera
110F
robotic
arm
114B
120
computer
system 102B

Figure 3B

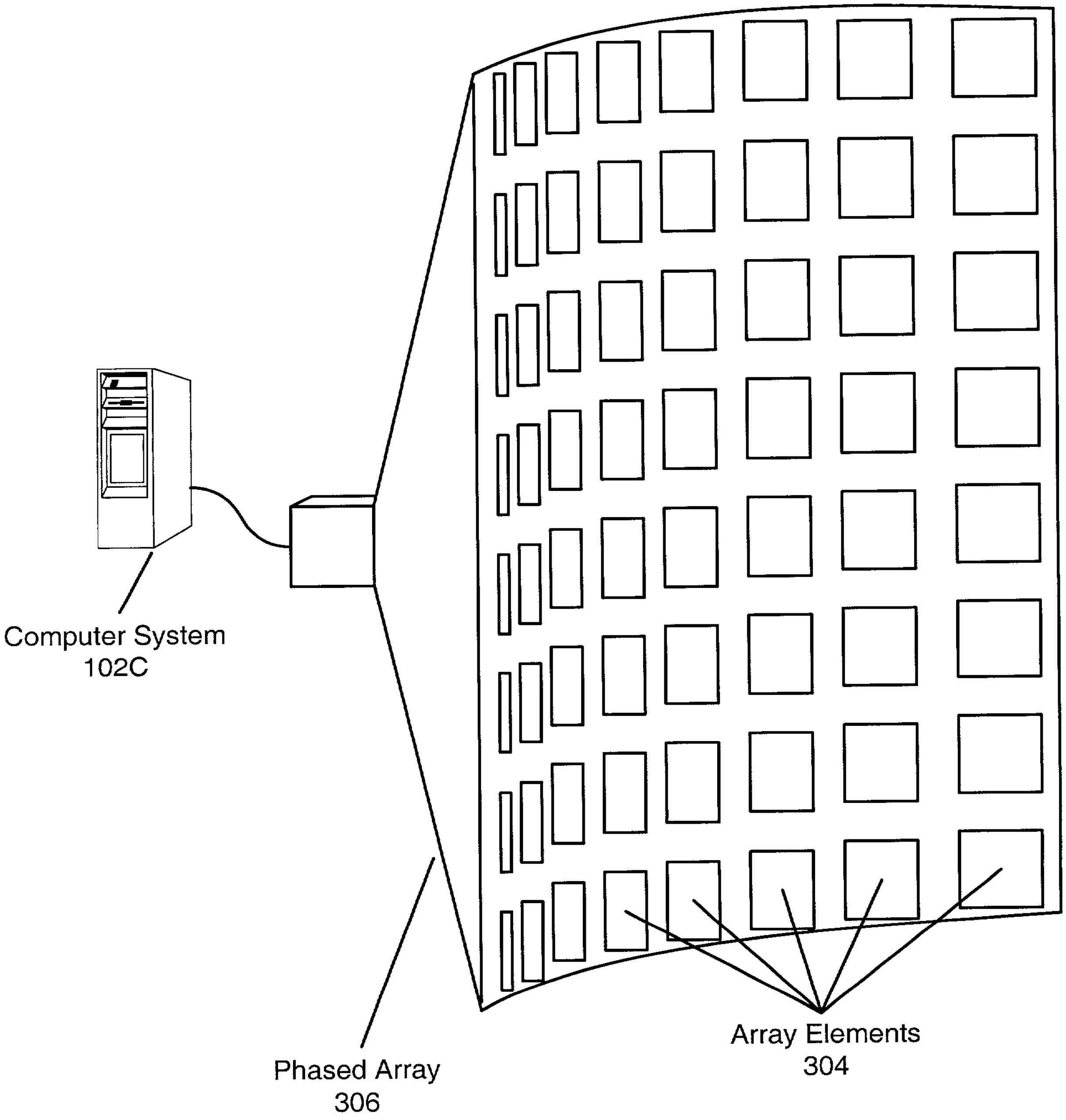


Figure 3C

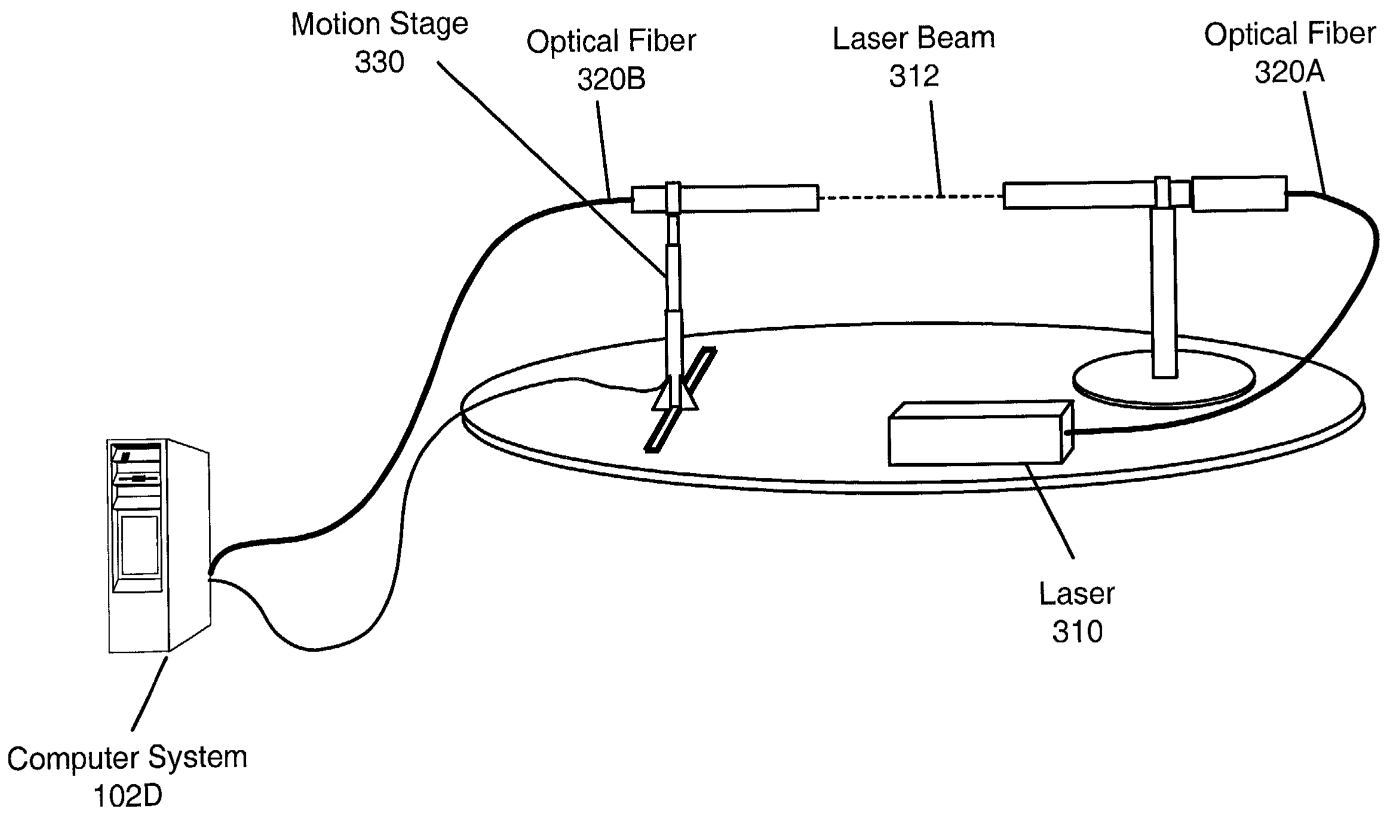
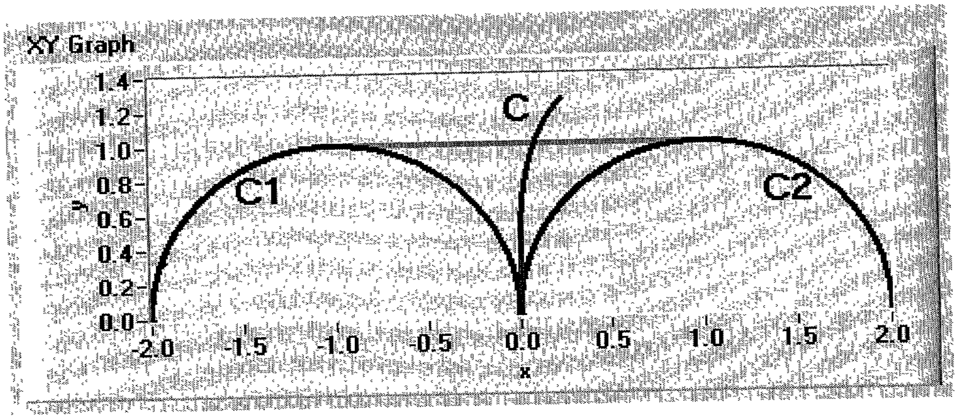
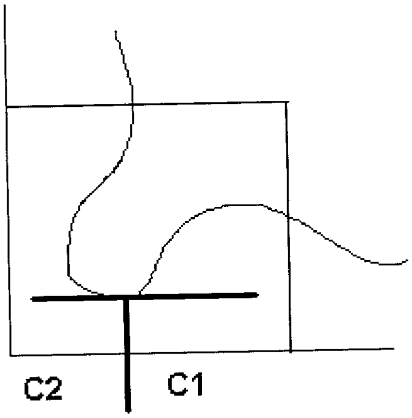

Motion Stage
330
Optical Fiber
320B
Laser Beam
312
Optical Fiber
320A
Laser
310
Computer System
102D

Figure 3D



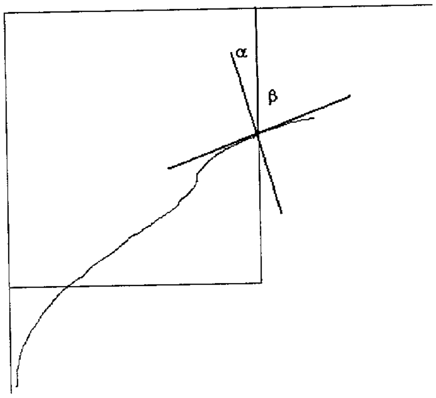
The situation of Lemma 1

Figure 4A



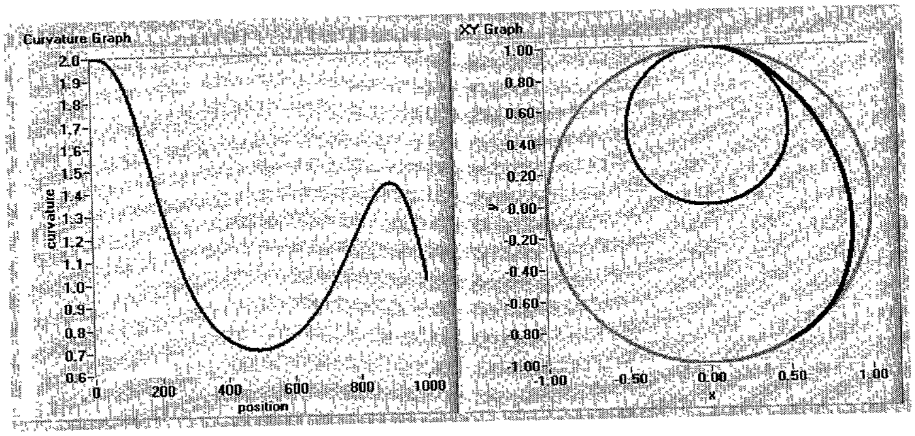
Case (A)

Figure 4B



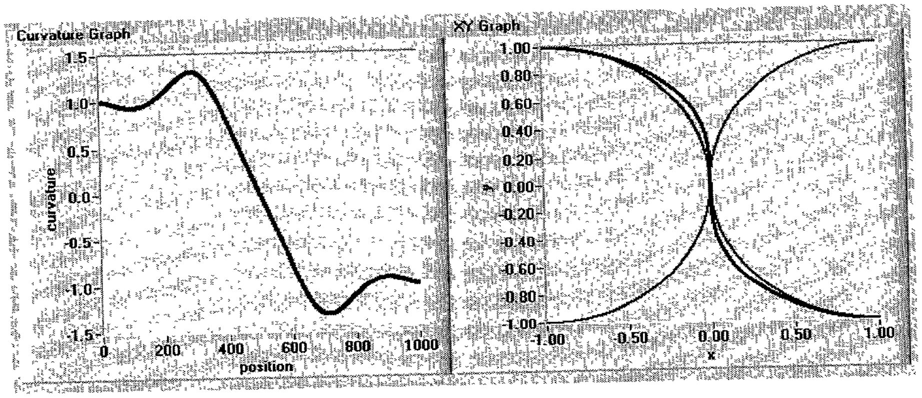
Case (B)

Figure 4C



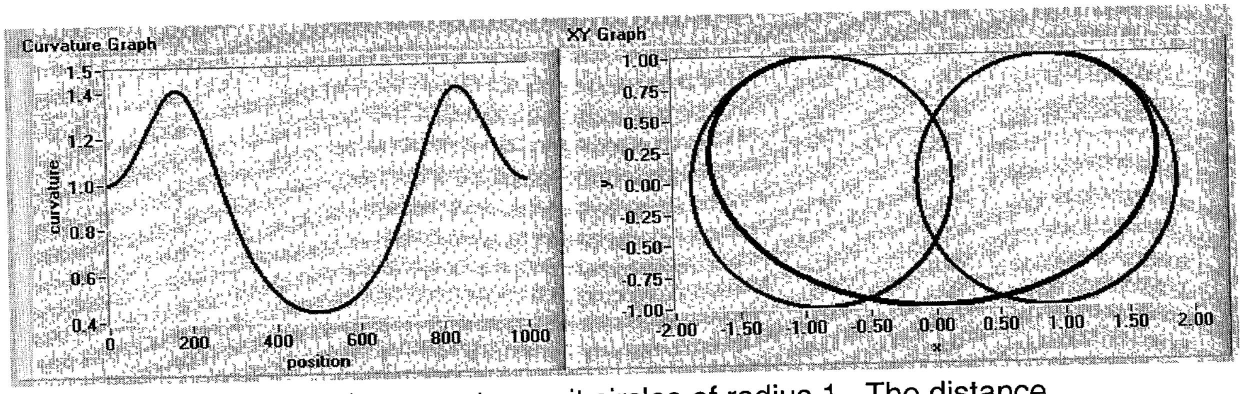
Smooth transition between two circles of different radii.

Figure 4D



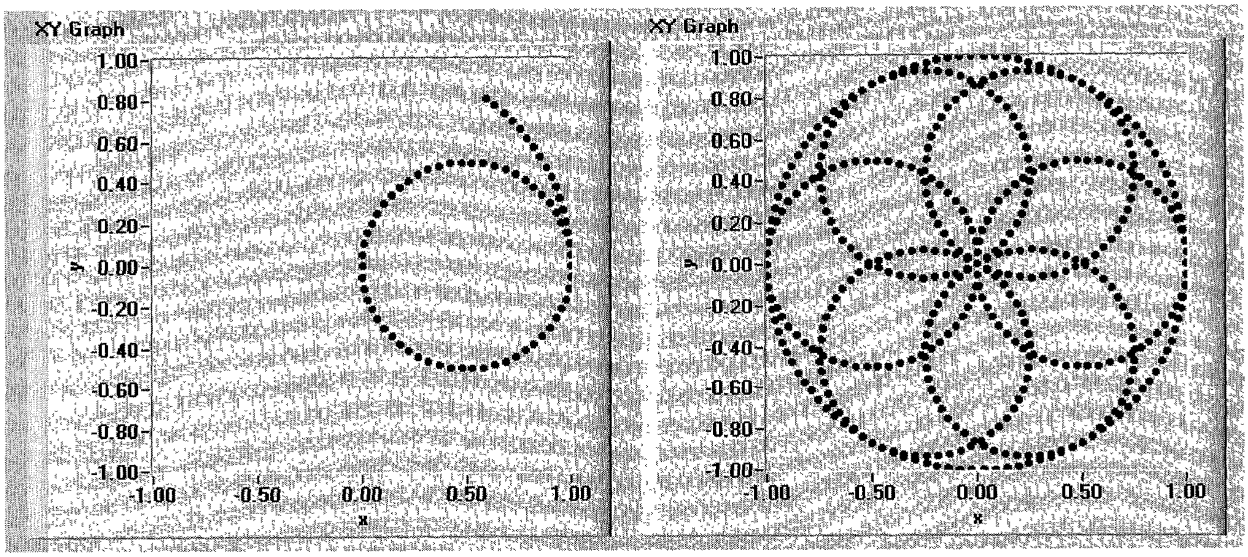
Smooth transition between two circles of same radius.

Figure 4E



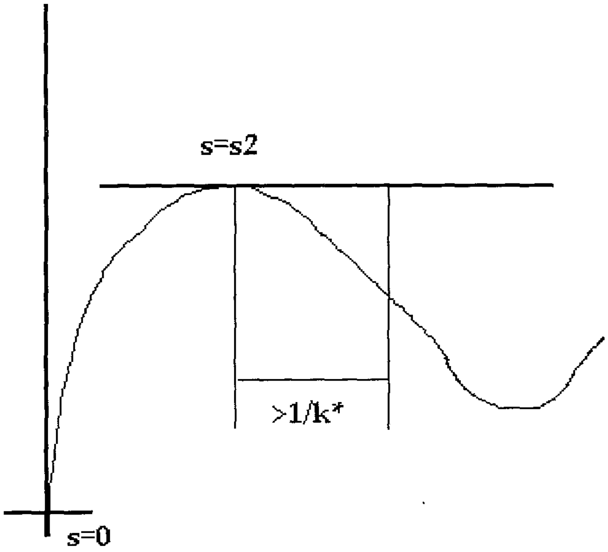
Transition between two unit circles of radius 1. The distance between the circles is sqrt(3)

Figure 4F



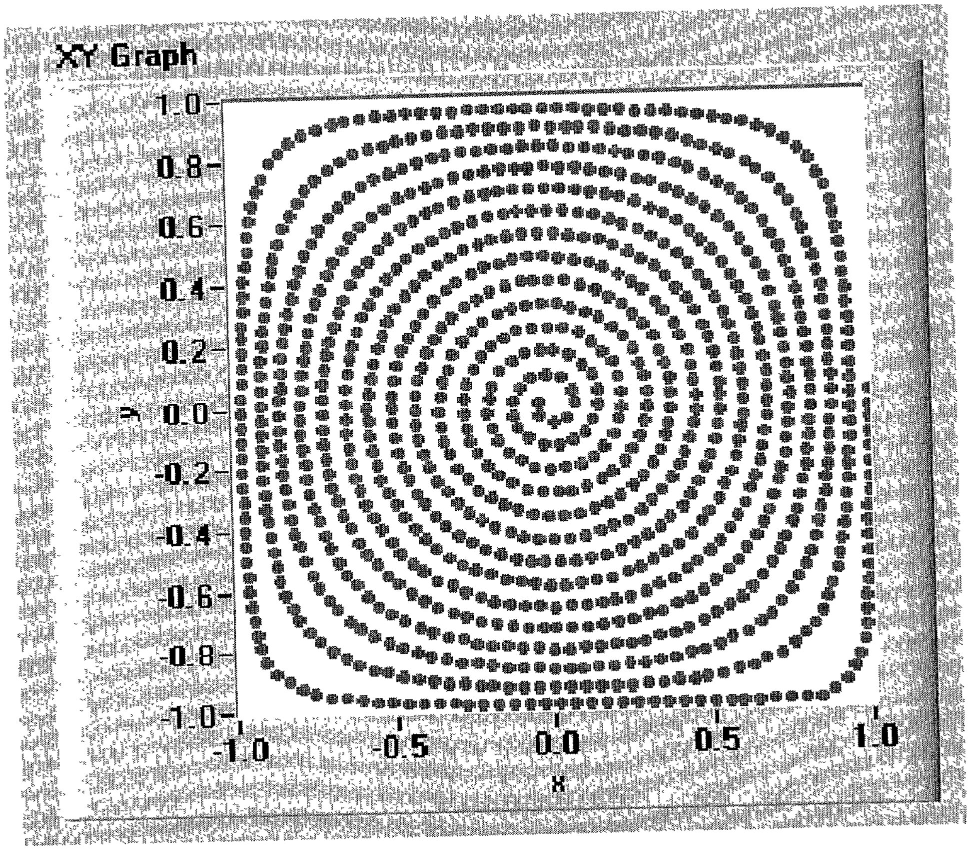
Beginning (left) and completion (right) of a scanning scheme where the curvature is below a certain value

Figure 5A



Construction of s2 and the subsequent part of the curve

Figure 5B



Conformal Spiral.

Figure 6

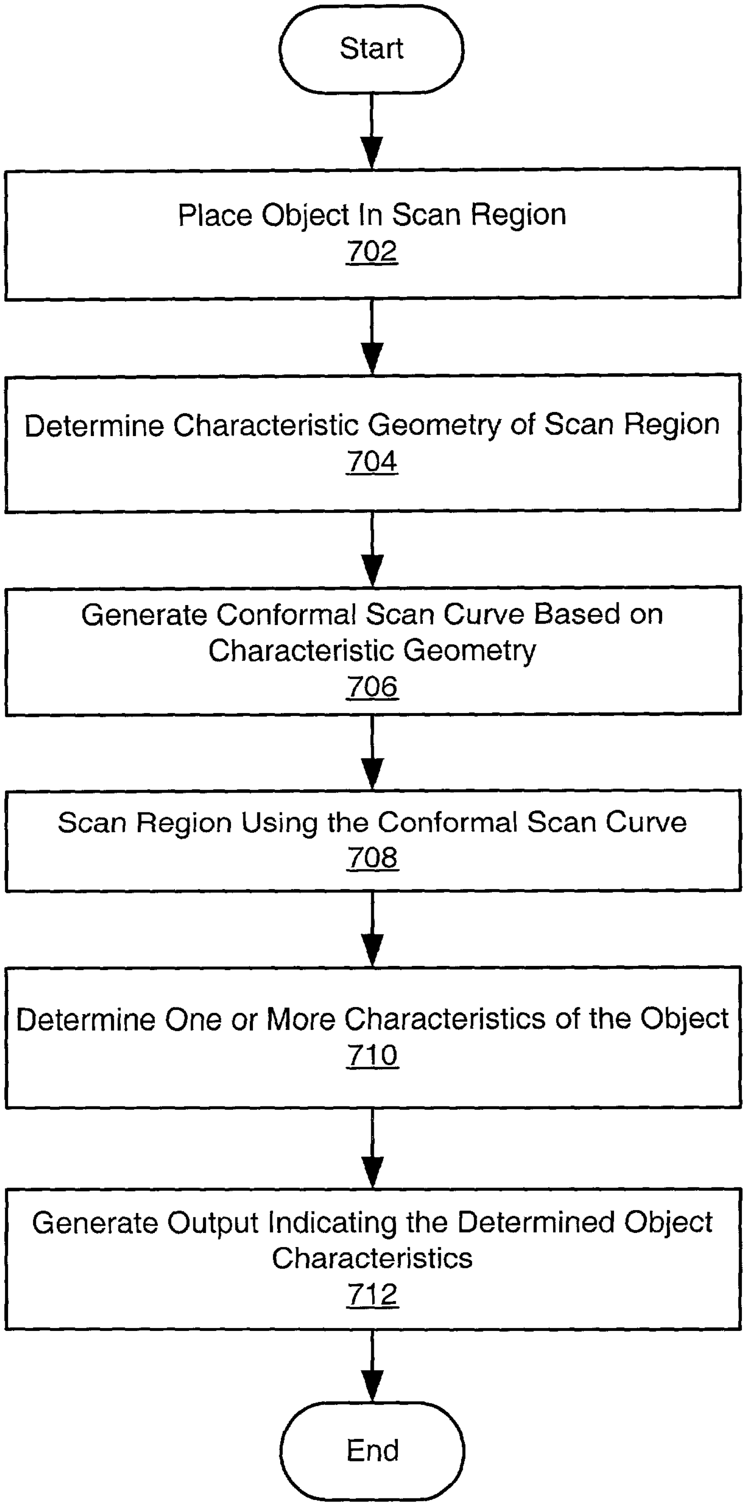
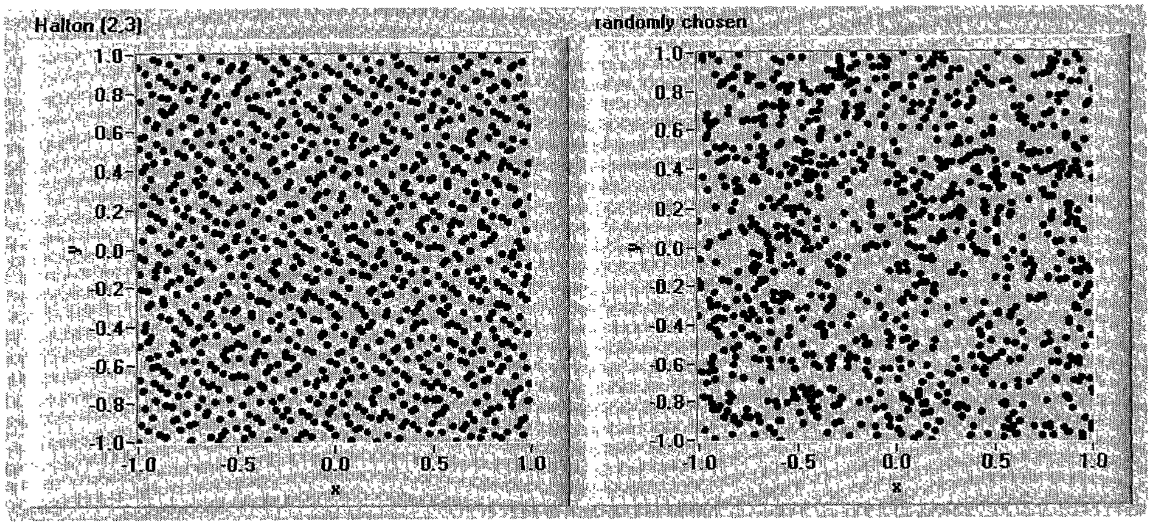
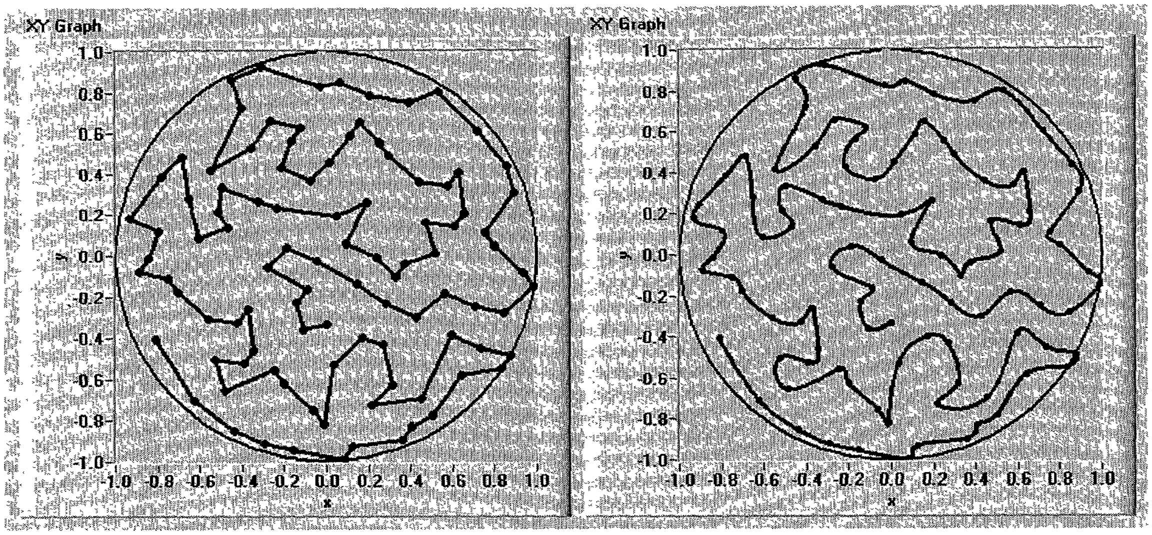

Start
Place Object In Scan Region
702
Determine Characteristic Geometry of Scan Region
704
Generate Conformal Scan Curve Based on Characteristic Geometry
706
Scan Region Using the Conformal Scan Curve
708
Determine One or More Characteristics of the Object
710
Generate Output Indicating the Determined Object Characteristics
712
End

Figure 07



The first 1000 Halton points (left) and randomly chosen points (right)

Figure 8A



Original solution (left) and splined version (right).

Figure 8B

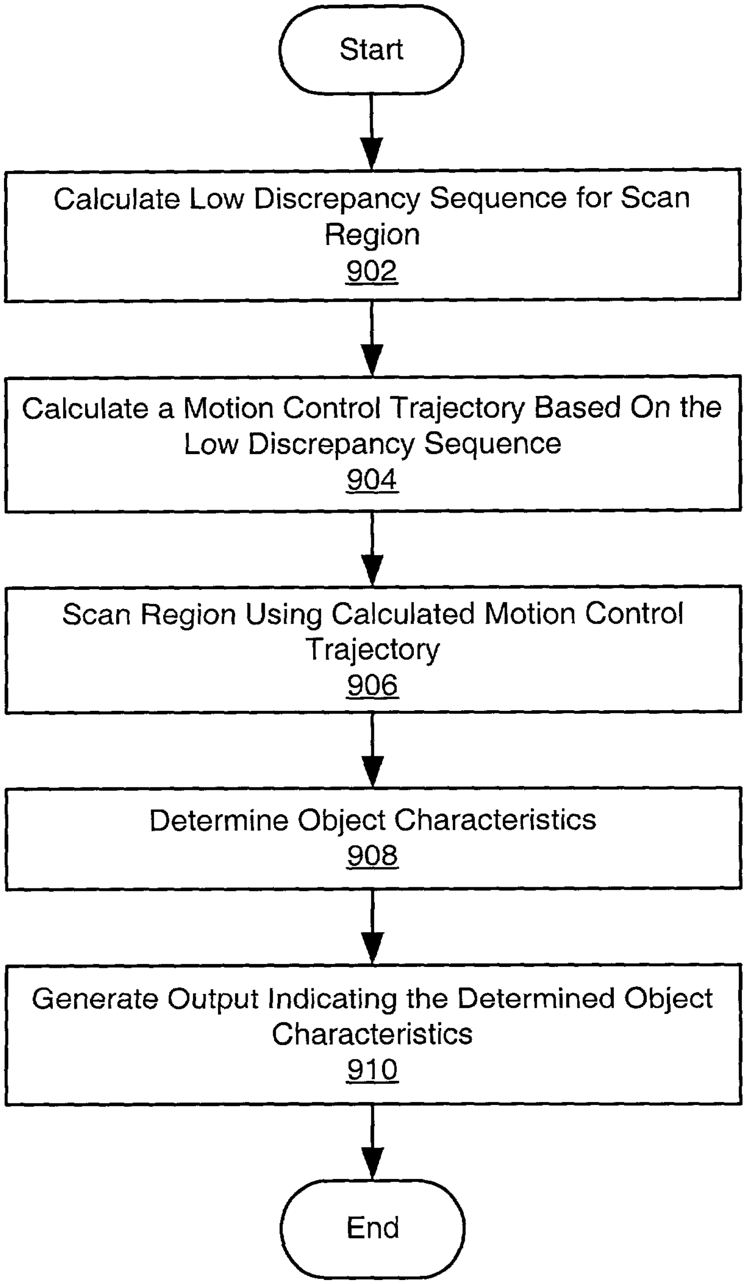
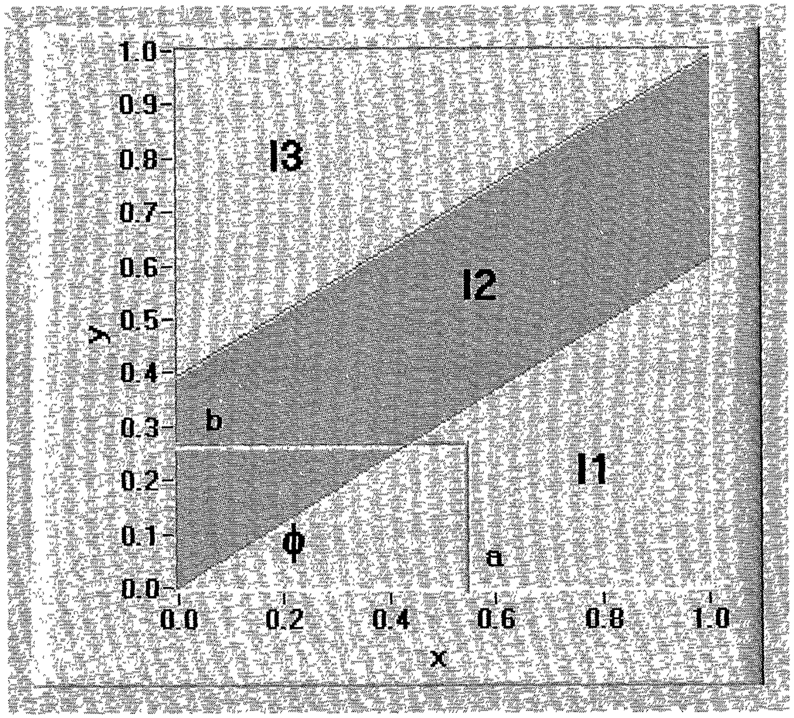

Start
Calculate Low Discrepancy Sequence for Scan Region
902
Calculate a Motion Control Trajectory Based On the Low Discrepancy Sequence
904
Scan Region Using Calculated Motion Control Trajectory
906
Determine Object Characteristics
908
Generate Output Indicating the Determined Object Characteristics
910
End

Figure 9



Definition of I_1, I_2, and I_3

Figure 10

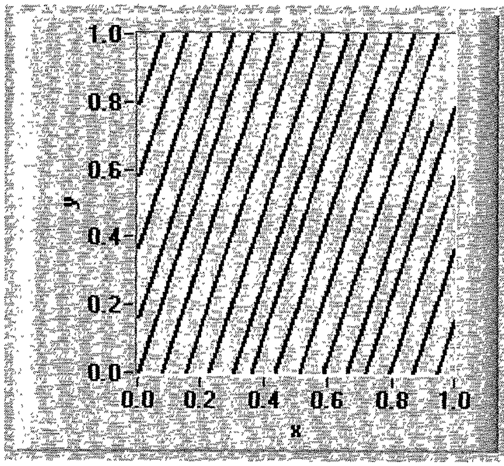


Figure 11A

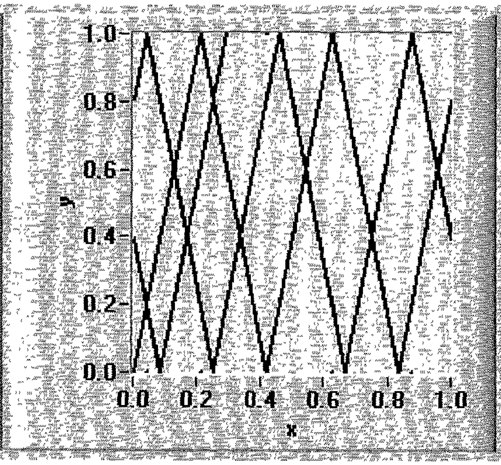


Figure 11B

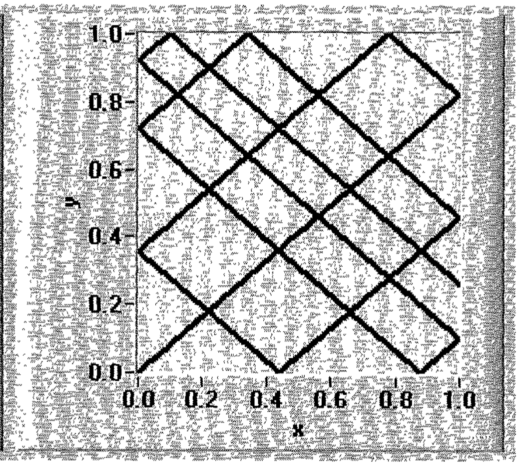


Figure 11C

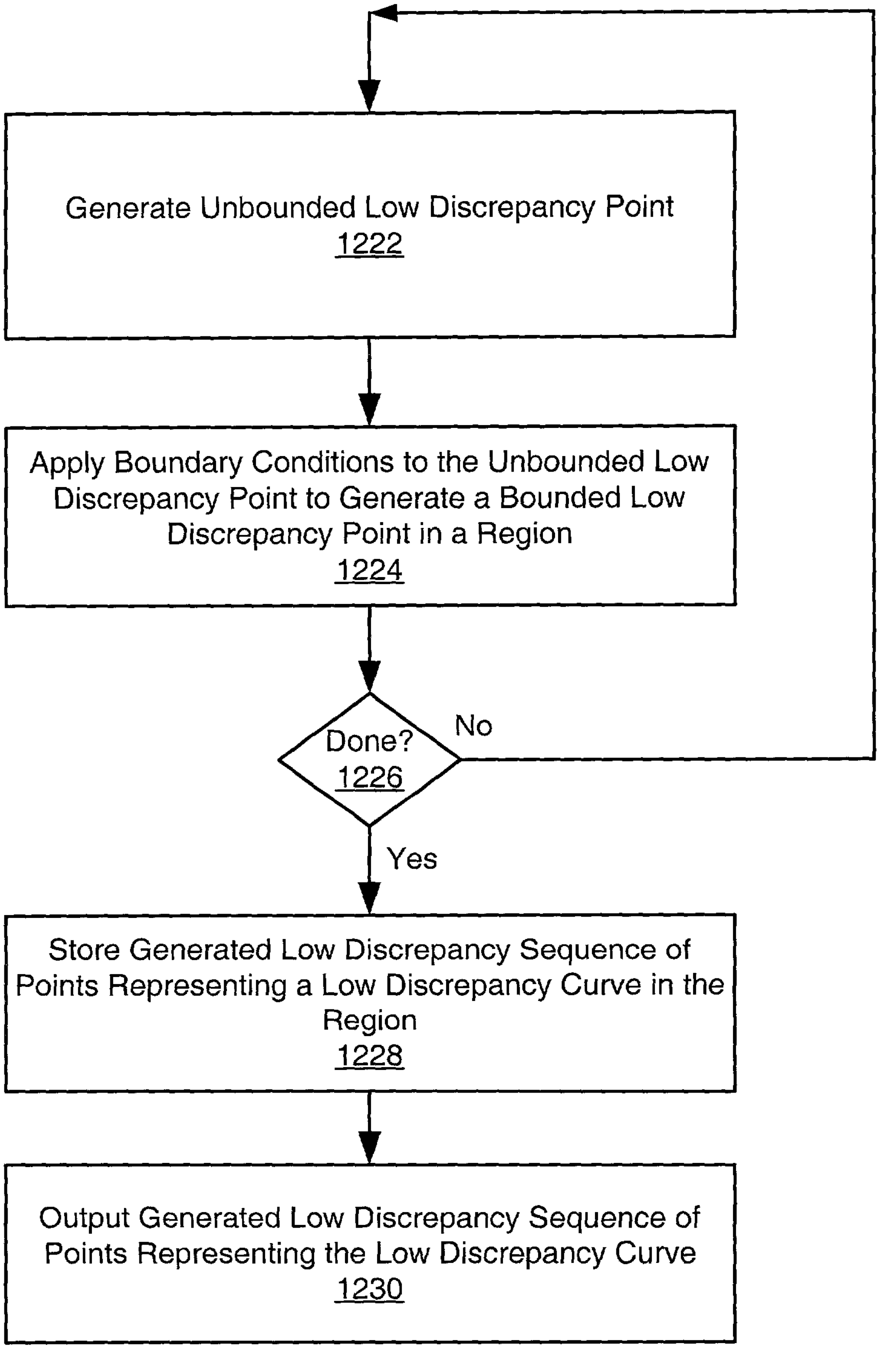

Generate Unbounded Low Discrepancy Point
1222
Apply Boundary Conditions to the Unbounded Low Discrepancy Point to Generate a Bounded Low Discrepancy Point in a Region
1224
Done?
1226
No
Yes
Store Generated Low Discrepancy Sequence of Points Representing a Low Discrepancy Curve in the Region
1228
Output Generated Low Discrepancy Sequence of Points Representing the Low Discrepancy Curve
1230

Figure 12A

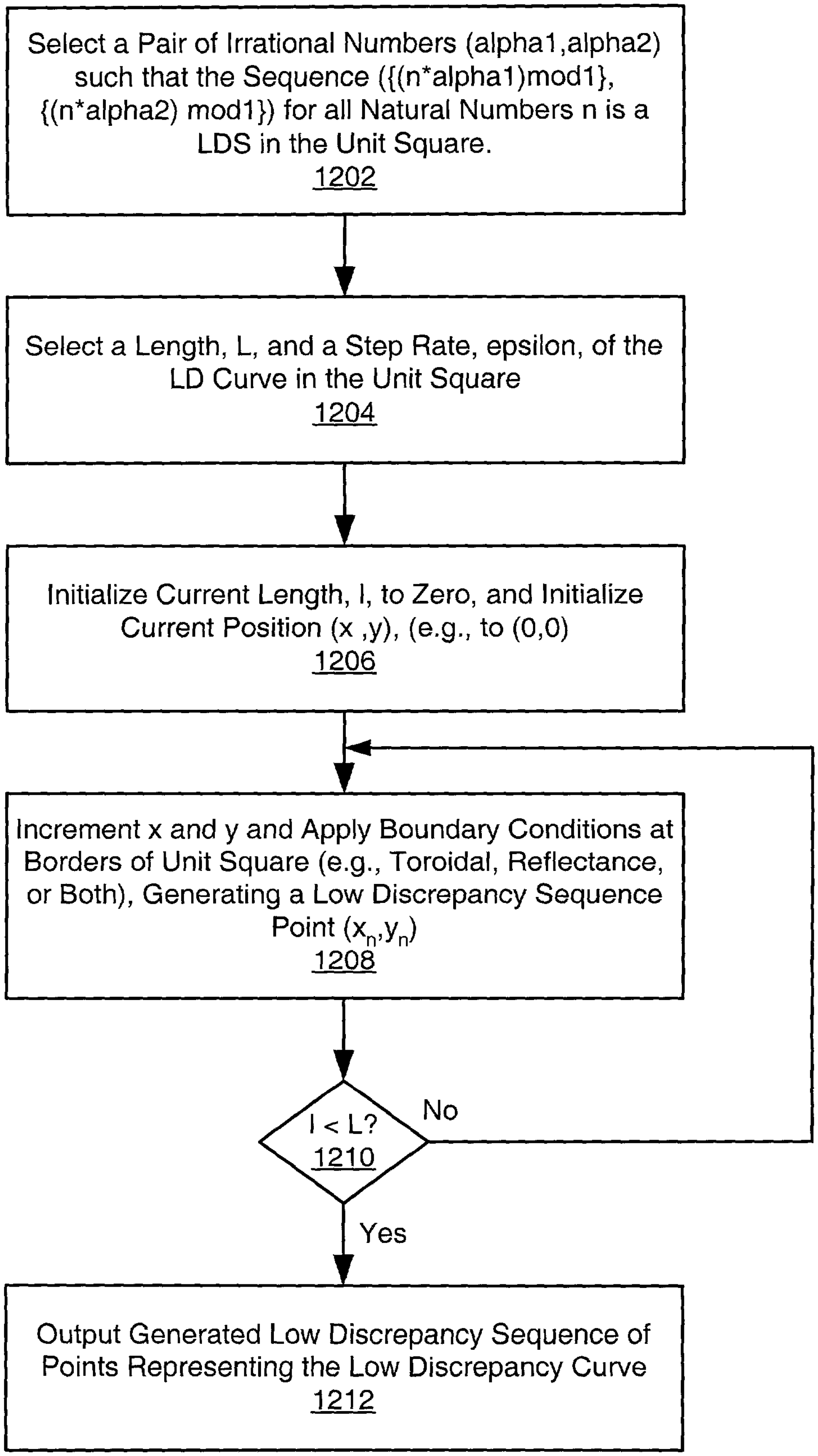
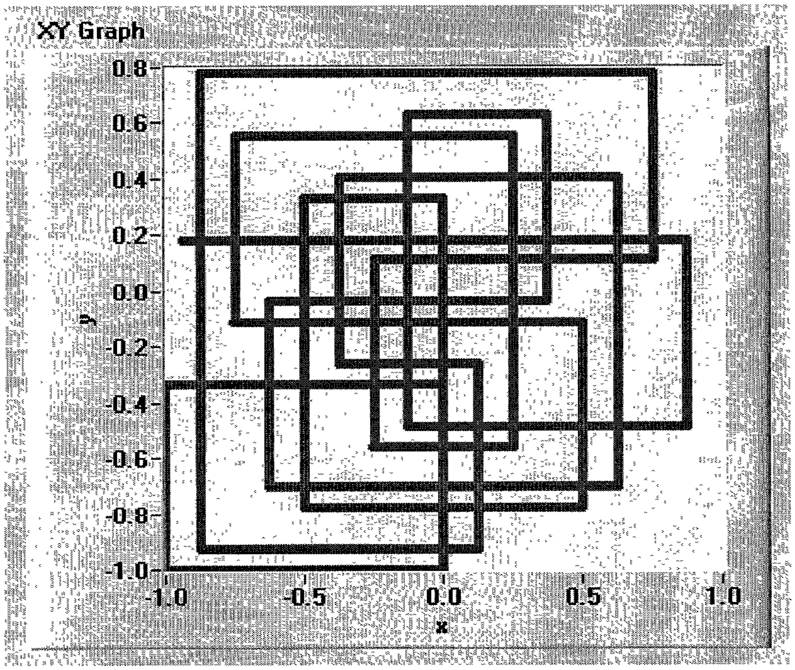
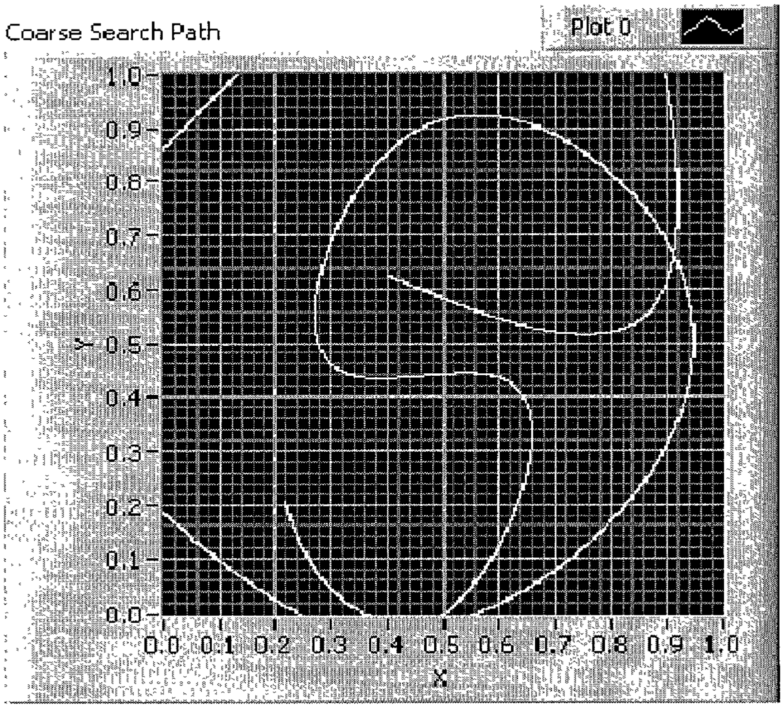

Select a Pair of Irrational Numbers (alpha1,alpha2) such that the Sequence ({(n*alpha1)mod1}, {(n*alpha2) mod1}) for all Natural Numbers n is a LDS in the Unit Square.
1202
Select a Length, L, and a Step Rate, epsilon, of the LD Curve in the Unit Square
1204
Initialize Current Length, l, to Zero, and Initialize Current Position (x ,y), (e.g., to (0,0)
1206
Increment x and y and Apply Boundary Conditions at Borders of Unit Square (e.g., Toroidal, Reflectance, or Both), Generating a Low Discrepancy Sequence Point (x_n,y_n)
1208
l < L?
1210
No
Yes
Output Generated Low Discrepancy Sequence of Points Representing the Low Discrepancy Curve
1212

Figure 12B



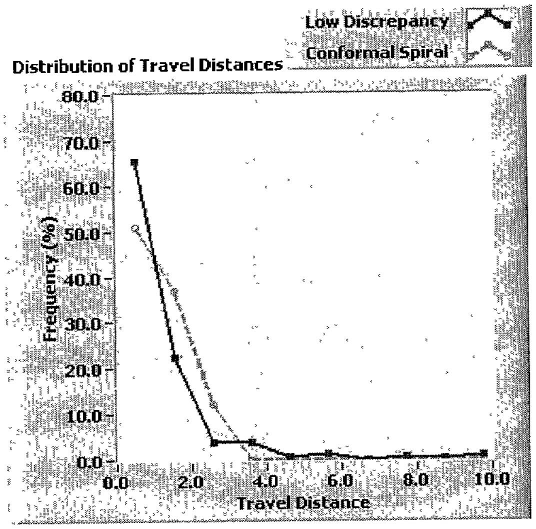
Beginning of a Low Discrepancy Curve based on a specific Halton Sequency in 2d

Figure 13A



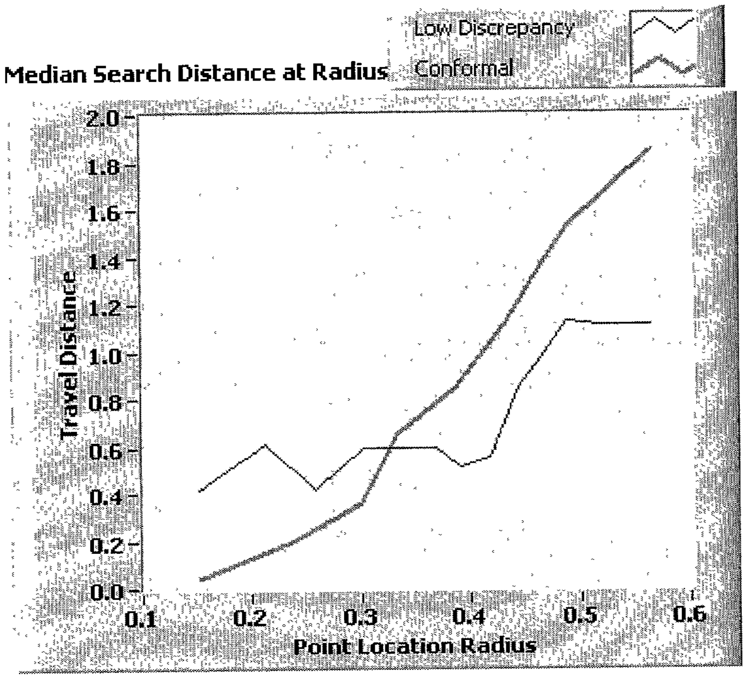
Splined Low Discrepancy Curve coarse search

Figure 13B



Comparison of Conformal Spiral and Low Discrepancy Searching

Figure 13C



Comparison of Travel Distance for Low Discrepancy Search and Conformal Spiral Search

Figure 13D

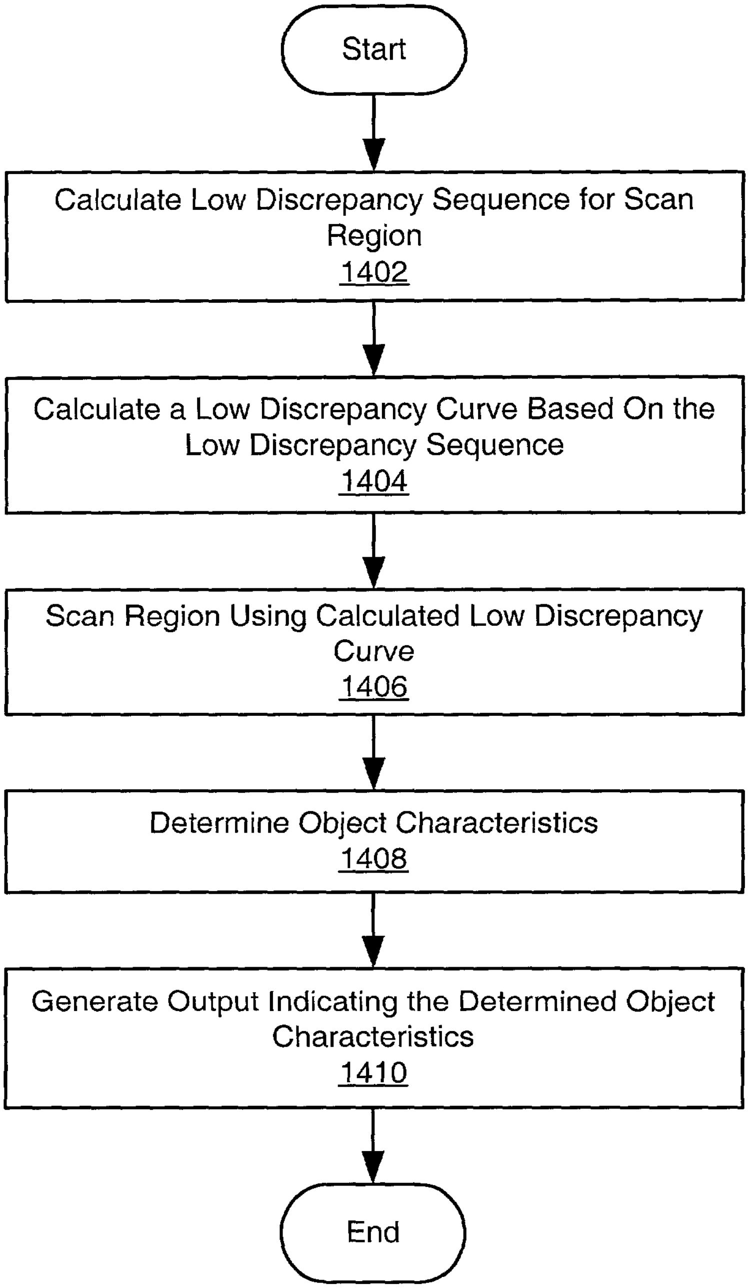
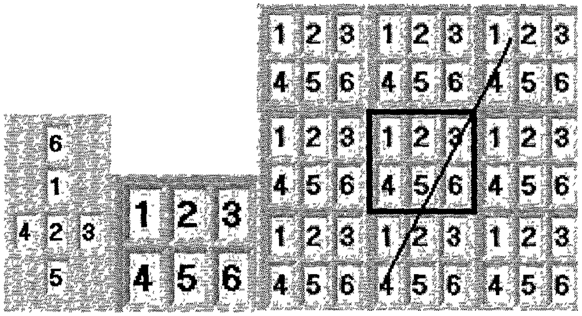
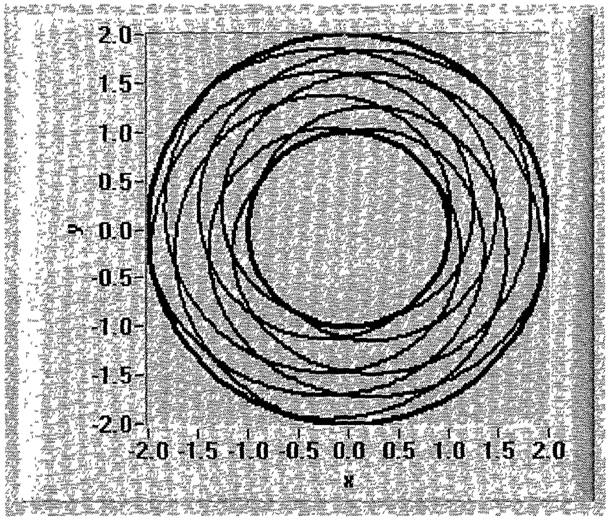

Start
Calculate Low Discrepancy Sequence for Scan Region
1402
Calculate a Low Discrepancy Curve Based On the Low Discrepancy Sequence
1404
Scan Region Using Calculated Low Discrepancy Curve
1406
Determine Object Characteristics
1408
Generate Output Indicating the Determined Object Characteristics
1410
End

Figure 14



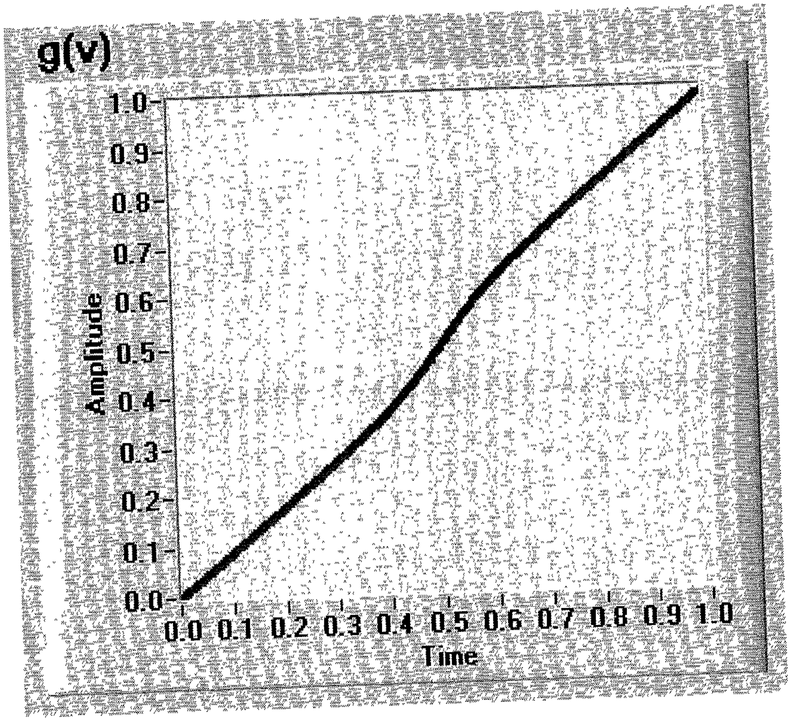
Tiling of the plane and relation to the surface of the unit cube

Figure 15A



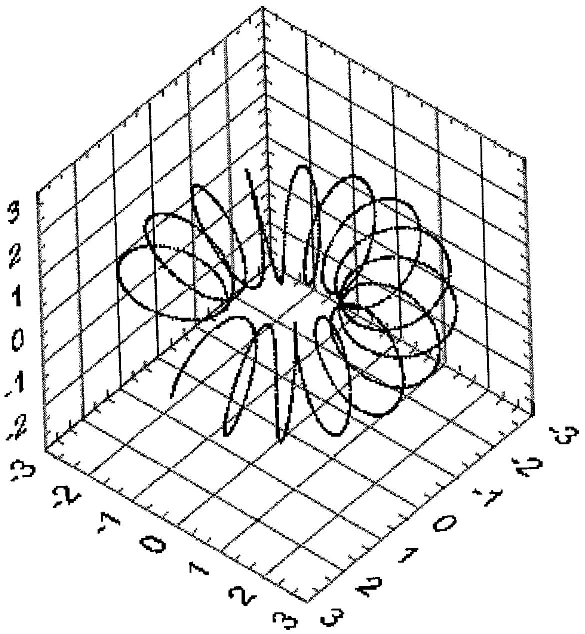
Low-discrepancy curve in a ring

Figure 15B



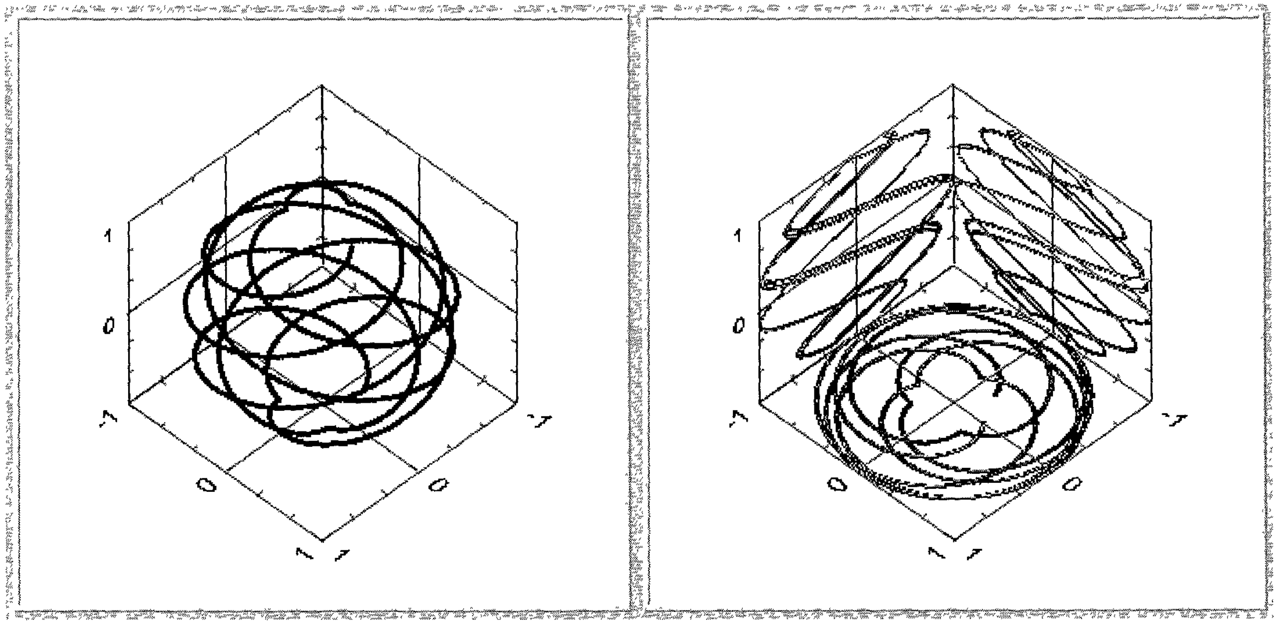
Low Discrepancy Preserving Mapping Function

Figure 15C



Low-discrepancy curve filling the surface of a torus

Figure 15D



Low-discrepancy curve on a sphere
(left) and projections (right)

Figure 16

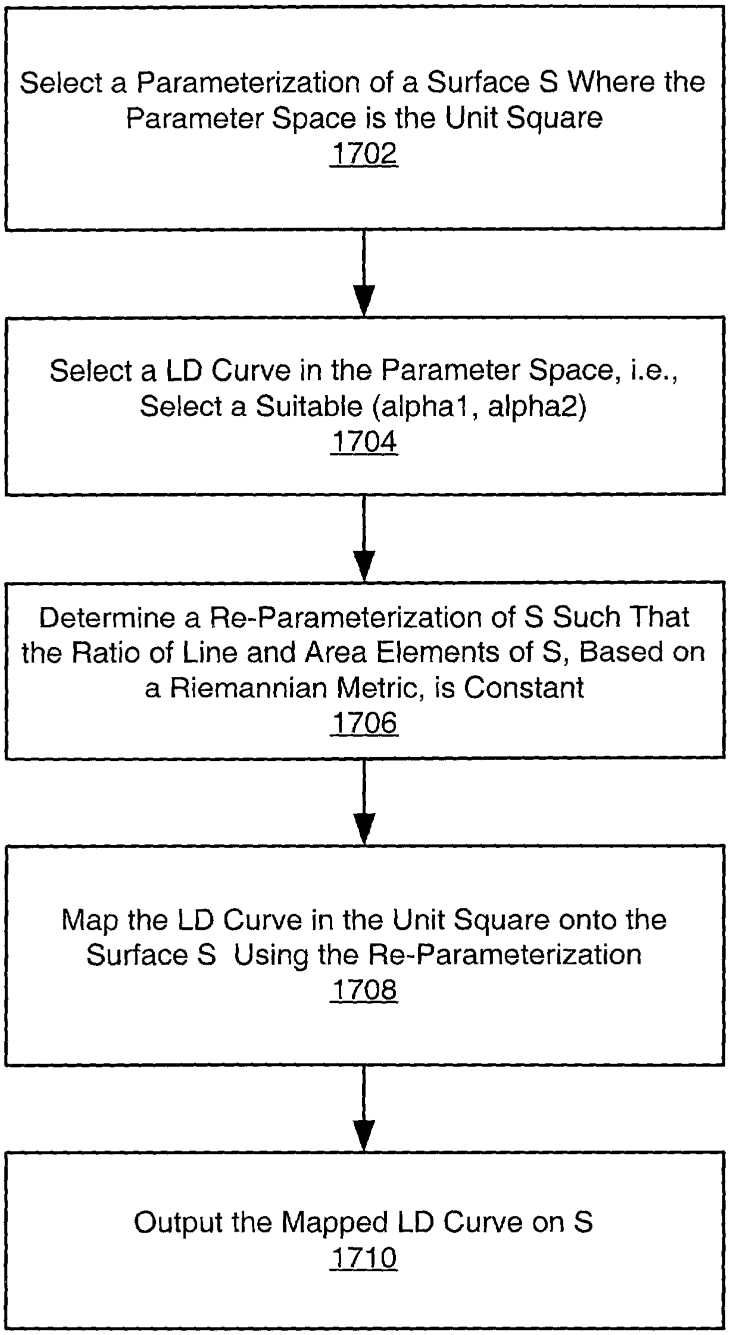
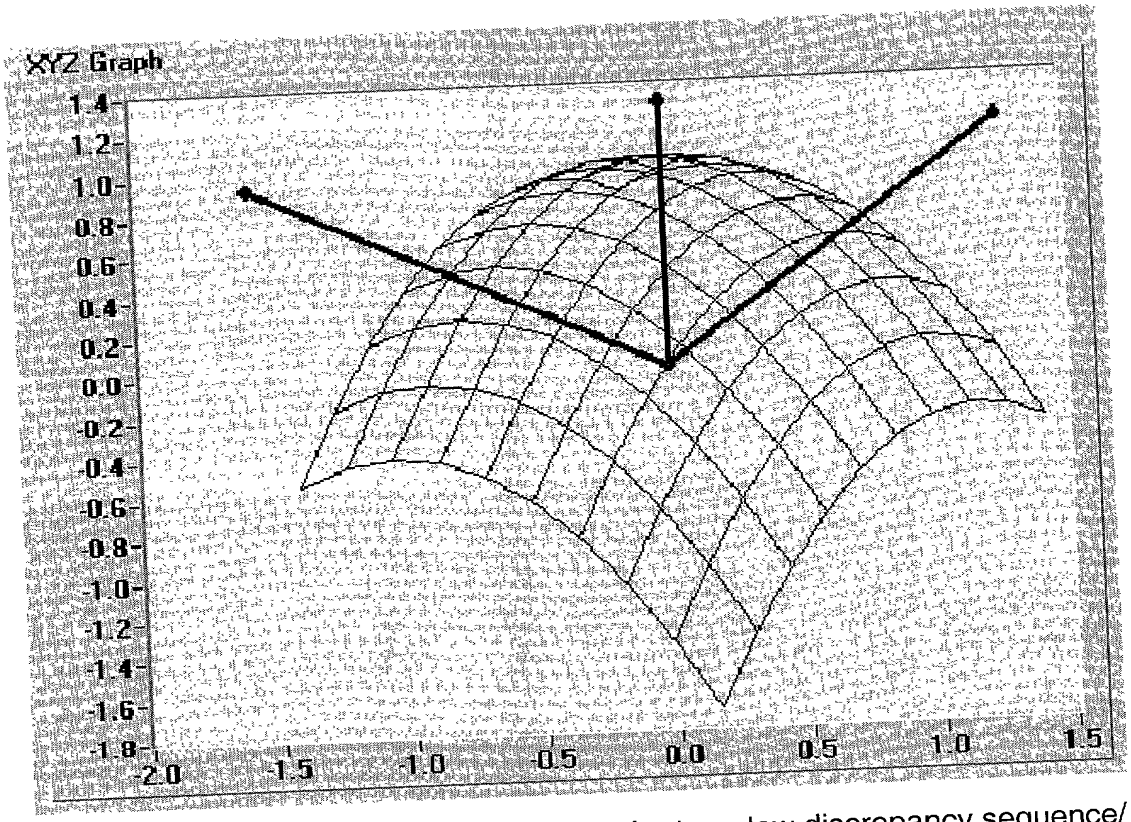
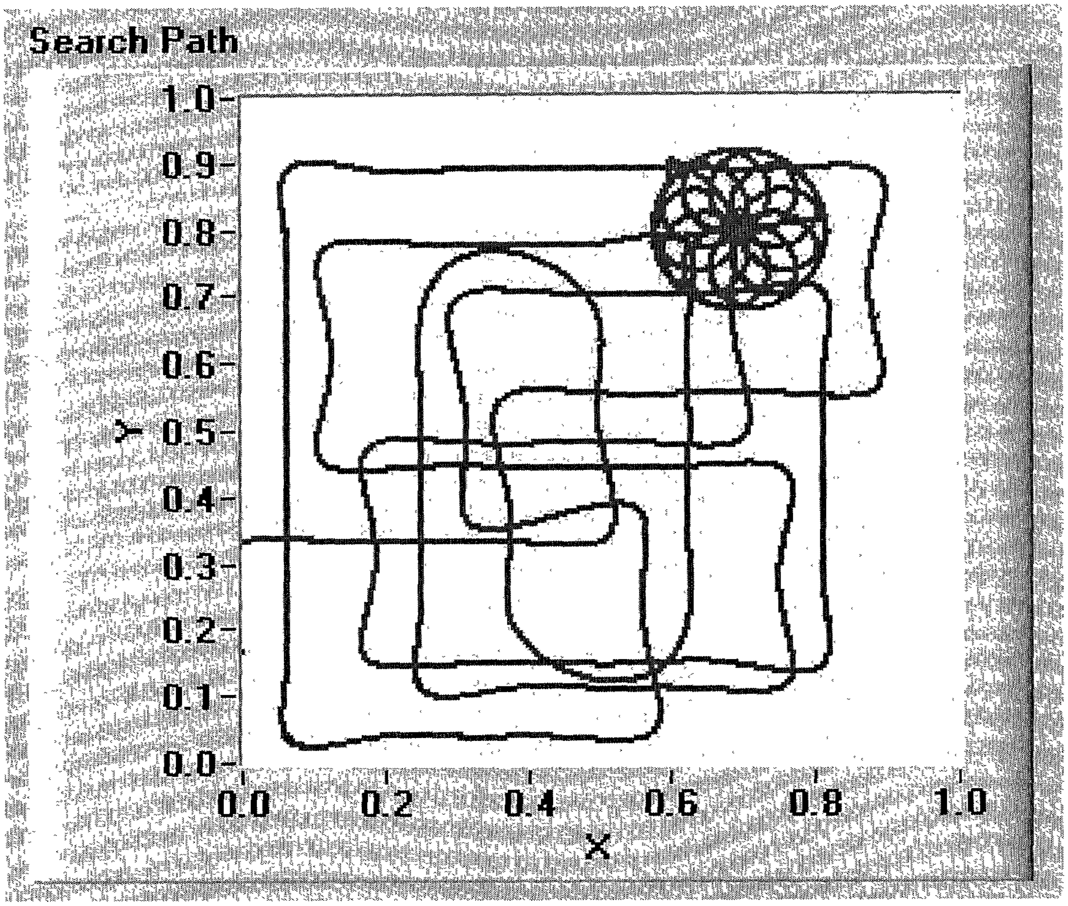

Select a Parameterization of a Surface S Where the Parameter Space is the Unit Square
1702
Select a LD Curve in the Parameter Space, i.e., Select a Suitable (alpha1, alpha2)
1704
Determine a Re-Parameterization of S Such That the Ratio of Line and Area Elements of S, Based on a Riemannian Metric, is Constant
1706
Map the LD Curve in the Unit Square onto the Surface S Using the Re-Parameterization
1708
Output the Mapped LD Curve on S
1710

Figure 17



Surfaces can be scanned efficiently when the term low discrepancy sequence/ curve can be generalized, e.g. based on metrics on the surface.

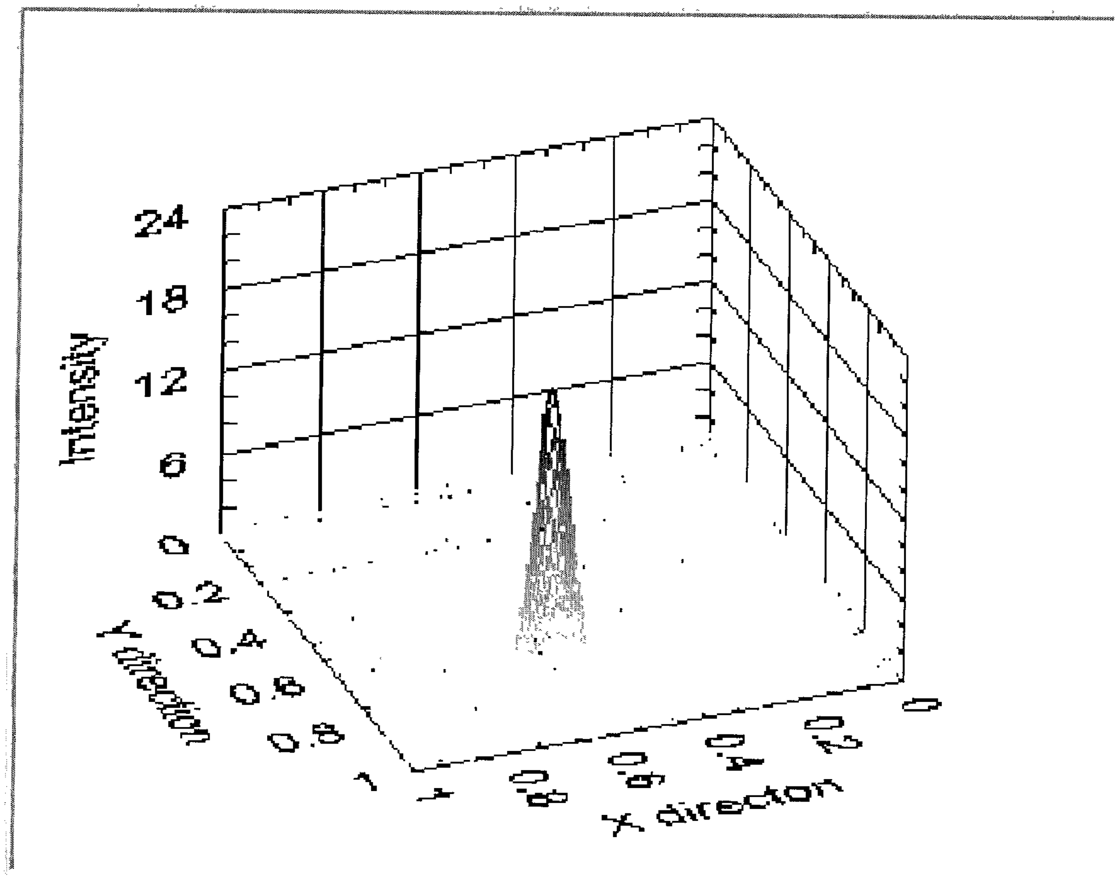
Figure 18



Splined Low Discrepancy Curve coarse search with refined final approach

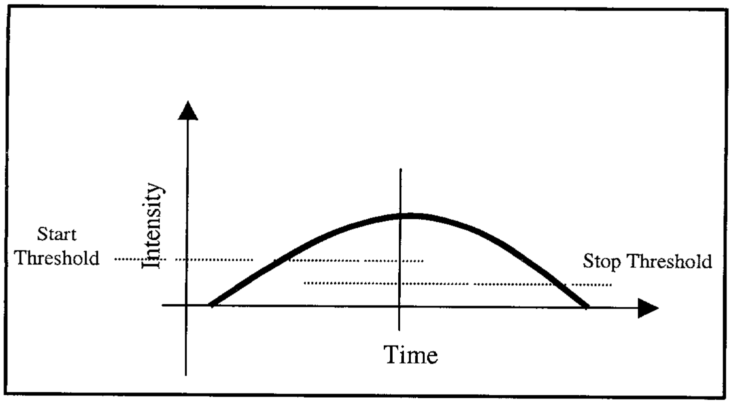
Figure 19

Intensity Field Distribution in Search Area



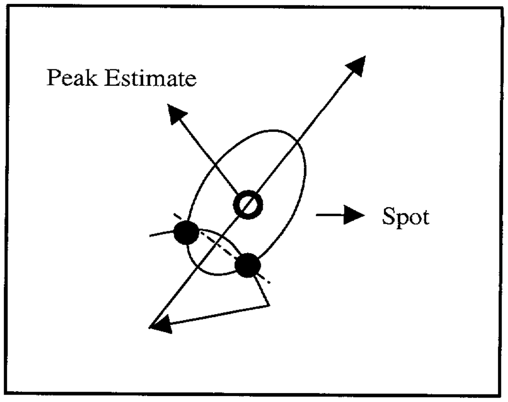
Beam intensity distribution in search area

Figure 20



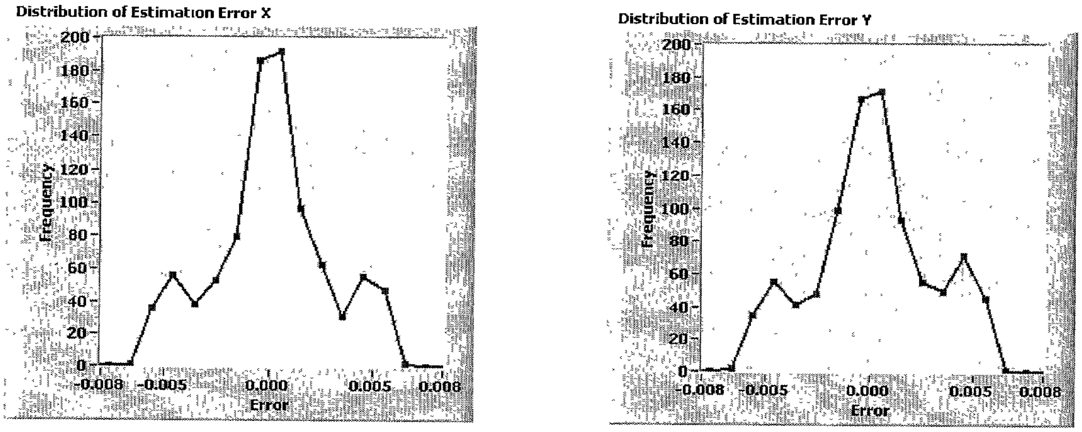
Location of the Peak

Figure 21A



Initial Final Approach Move

Figure 21B



Error distribution of the estimated peak X coordinate error (left) and Y coordinate error (right)

Figure 21C

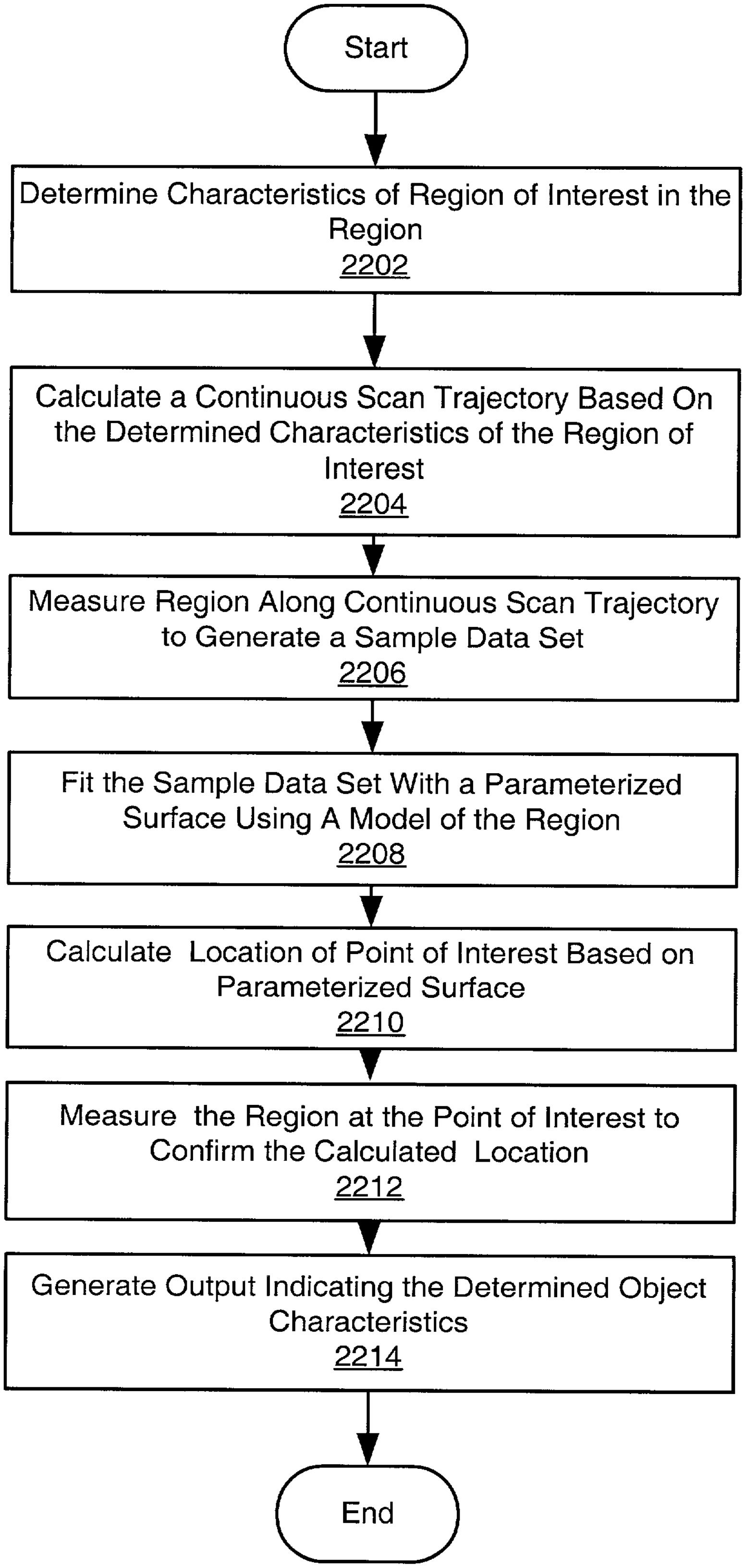

Start
Determine Characteristics of Region of Interest in the Region
2202
Calculate a Continuous Scan Trajectory Based On the Determined Characteristics of the Region of Interest
2204
Measure Region Along Continuous Scan Trajectory to Generate a Sample Data Set
2206
Fit the Sample Data Set With a Parameterized Surface Using A Model of the Region
2208
Calculate Location of Point of Interest Based on Parameterized Surface
2210
Measure the Region at the Point of Interest to Confirm the Calculated Location
2212
Generate Output Indicating the Determined Object Characteristics
2214
End

Figure 22

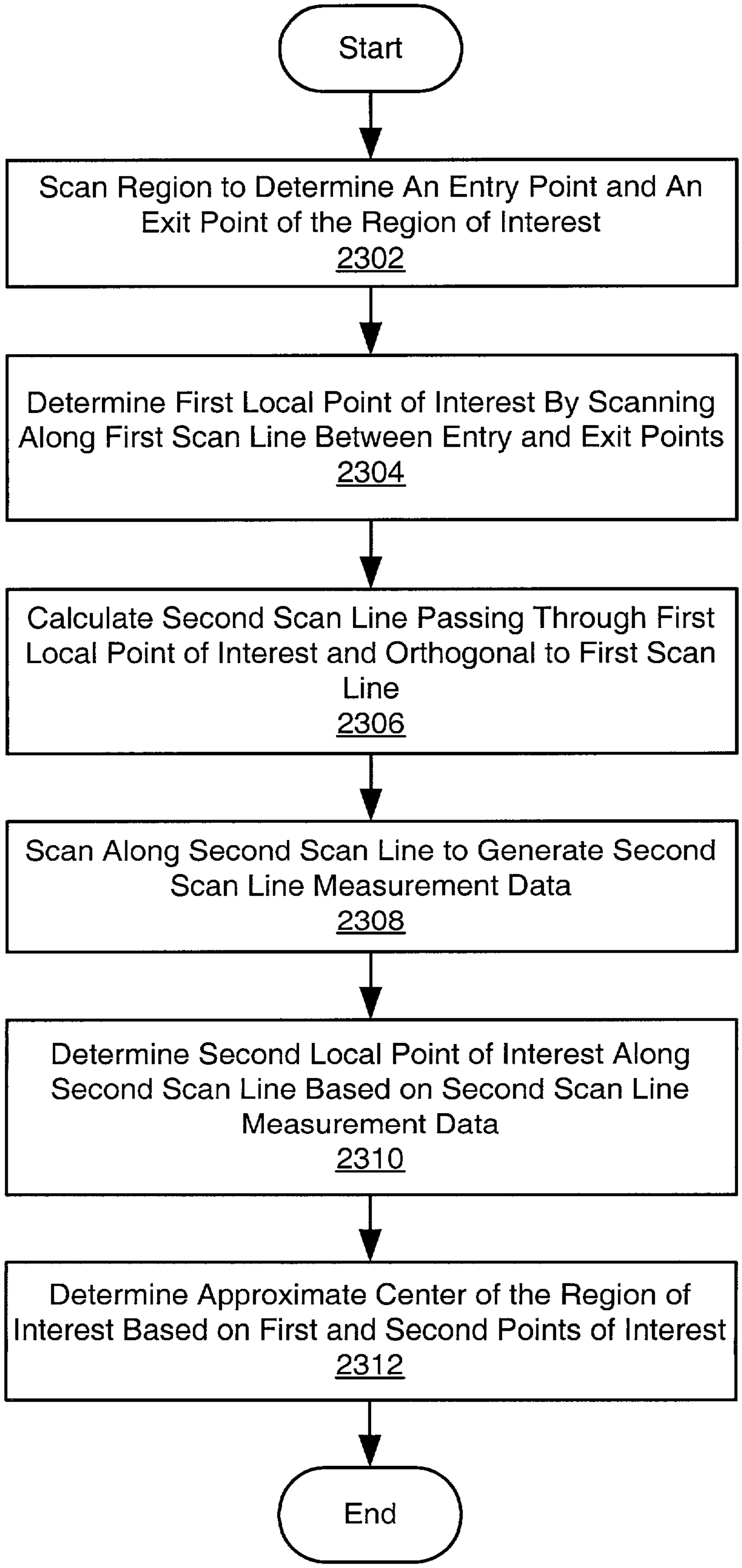

Start
Scan Region to Determine An Entry Point and An Exit Point of the Region of Interest
2302
Determine First Local Point of Interest By Scanning Along First Scan Line Between Entry and Exit Points
2304
Calculate Second Scan Line Passing Through First Local Point of Interest and Orthogonal to First Scan Line
2306
Scan Along Second Scan Line to Generate Second Scan Line Measurement Data
2308
Determine Second Local Point of Interest Along Second Scan Line Based on Second Scan Line Measurement Data
2310
Determine Approximate Center of the Region of Interest Based on First and Second Points of Interest
2312
End

Figure 23